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INVESTIGATIONS OF SPRAYS FOR CONTROL OF THE EUROPEAN CORN BORER, TOLEDO, OHIO, 1945-1946

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Investigations of insecticides applied as sprays for control of the European corn borer (Pyrausta nubilalis (Hbn.)) were continued during the seasons of 1945 and 1946 in the vicinity of Toledo, Ohio, and the results obtained are presented herewith.

Small-Plot Tests

Small plots were laid out in randomized blocks, each plot being 4 rows wide and 20 feet long, and each treatment was replicated 4 times. A wheelbarrow sprayer powered with a gasoline engine and equipped with nozzles that produce solid cones of spray was used in the application of water suspensions. All buffer rows were treated with a spray containing ground cube root (4.8 percent rotenone) applied with a self-propelled boom sprayer. All the insecticides were tested as water suspensions, and sodium butylhydroxyphenylbenzene sulfonate (Areskap) was used as the wetting agent at the rate of 1/3 pound per 100 gallons of water. The plants were thoroughly sprayed, enough spray being applied to cause free run-off at the base of each plant. The quantities used were increased during the season as the plants grew larger. No accurate record of the gallons used per acre was practical, but the dosage was estimated at 150-175 gallons per acre in 1945 and 170 gallons in 1946.

In 1945 borer development was late but corn development was later. The egg-hatching period began in the earliest fields on June 25, or 10 days later than in 1944, and ended after July 11, 11 or more days later than in 1944. The first spray application was made on June 29, when the corn was 9 inches high. This is in contrast with the 1944 season, in which the first application was made on June 17, when the corn was 36 inches high. Additional applications in 1945 were made on July 4, 9, and 14. Only slightly more than 1 inch of rain fell during the spraying season.

In 1946 egg hatching began on June 25, and the first spray was applied on June 28, when the corn was 38 inches high with tassels beginning to emerge. Three additional applications were made on July 3, 8, and 13. At the time of the second application the corn was fully tasseled and silking.

In both years 100 corn plants, 25 from each plot, for each treatment were dissected at the roasting-ear stage to determine the effectiveness of the treatments. The results are presented in tables 1 and 2.

In 1945 the compounds 1-isobutyryl-2-phenylhydrazine and 1-phenyl-2-(phenylsulfonyl) hydrazine were among the more effective of the insecticides tested. 1-Trichloro-2,2-bis(3,5-dichloro-2-hydroxyphenyl)-ethane, tetrachlorodiphenylethane, benzene hexachloride, and 1-phenyl-semioxamazide were apparently somewhat less effective, though not significantly so, at odds of 19 to 1. Both bis(3,5,6-trichloro-2-hydroxyphenyl)methane and 1-phenyl-2-(p-tolysulfonyl)hydrazine greatly reduced borer populations in both plants and ears, but were significantly less effective than the first eight materials listed. However, a rather heavy dosage of all these chemicals except benzene hexachloride was used.

The particle size of the high-rotenone (9.6 percent) cube powder tested in 1945 was very small (300-500 mesh). Although this material gave satisfactory control, it did not reduce the borer population in the plants so much as did the cube of lower rotenone content which had a somewhat larger particle size.

Ryania, 1-trichloro-2,2-bis(3,5-dichloro-2-hydroxyphenyl)ethane, 1-phenyl-2-(phenylsulfonyl)hydrazine, cube, and DDT gave good spray suspensions. The remaining materials gave poor to medium suspensions.

Of the nine materials tested in 1946, five showed very promising results. Chlorinated camphene and 2,2-bis(3-bromo-5-chloro-2-hydroxyphenyl)-1-trichloroethane were both about as effective as DDT but were used at considerably heavier dosages.

The sample of methoxy analog of DDT (trichloro-bis(methoxyphenyl)-ethane) used in these tests was highly effective, although a different, highly purified sample that was tested at the same strength in the laboratory during the winter of 1945 caused no appreciable mortality of corn borer larvae. In view of these results, a comparative test of both samples was run in the laboratory. The 1945 material again caused no mortality, whereas the 1946 material was quite toxic at low concentrations. This discrepancy was apparently due to some difference in the preparation of the two samples.

Table 1.—Small-plot tests in 1945 of new materials to determine their insecticidal value in European corn borer control

Formulation	Mixture or chemical per 100 gallons	Active ingredient		Yield of No. 1 ears per 100 plants		Borers in ears[1] from 100 plants	Borers per 100 plants[2]	Reduction of borers in—	
		Per 100 gallons	Per acre-application	Total	Borer-free			Ears	Plants
	Pounds	Pounds	Pounds	Number	Percent	Number	Number	Percent	Percent
DDT (technical) 25 percent, micronized on fuller's earth	2	0.5	0.75–0.88	102	98	2	4	99	99
Ryania speciosa	4	4.0	6.0 –7.0	102	98	4	16	98	97
DDT (technical) 5 percent, fused with sulfur	8	.4	0.6 –0.7	106	98	2	18	99	96
Cube powder (4.8 percent rotenone)	4	.15	0.23–0.26	100	98	4	24	98	95
1-Isobutyryl-2-phenylhydrazine 50 percent on kaolin	8	4.0	6.0 –7.0	102	98	8	30	96	94
Cube powder (9.6 percent rotenone)	2.2	.21	0.32–0.37	100	98	2	32	99	94
1-Phenyl-2-(phenylsulfonyl)hydrazine 50 percent on kaolin	8	4.0	6.0 –7.0	102	98	2	32	99	94
1-Trichloro-2,2-bis(3,5-dichloro-2-hydroxyphenyl)ethane 50 percent on pyrophyllite	8	4.0	6.0 –7.0	100	90	10	54	95	89
Tetrachlorodiphenylethane 50 percent in talc	8	4.0	6.0 –7.0	100	94	14	56	92	89

Table 1.--(Continued)

Formulation	Mixture or chemical per 100 gallons	Active ingredient		Yield of No. 1 ears per 100 plants		Borers in ears[1] from 100 plants	Borers per 100 plants[2]	Reduction of borers in—	
		Per 100 gallons	Per acre-application	Total	Borer-free			Ears	Plants
	Pounds	Pounds	Pounds	Number	Percent	Number	Number	Percent	Percent
Benzene hexachloride (technical) 20 percent in gypsum (approximately 2% gamma isomer)	8	1.6	2.4 -2.8	102	96	6	56	97	89
1-Phenylsemioxamazide 50 percent on kaolin	8	4.0	6.0 -7.0	102	98	8	56	96	89
Bis(3,5,6-Trichloro-2-hydroxyphenyl)methane 50 percent on pyrophyllite	8	4.0	6.0 -7.0	100	90	16	84	91	84
1-Phenyl-2-(p-tolylsulfonyl)hydrazine 50 percent on kaolin	8	4.0	6.0 -7.0	98	84	22	136	88	73
Check (untreated)	-	-	-	106	32	182	510	-	-
Difference required for significance at odds of 19 to 1	-	-	-	-	-	-	62	-	-

1/ All ears including culls.
2/ Does not include tillers.

Table 2.--Small-plot tests in 1946 of new materials to determine their insecticidal value in European corn borer control

Formulation	Mixture or chemical per 100 gallons	Active ingredient		Yield of No. 1 ears per 100 plants		Borers in ears from 100 plants[1]	Borers per 100 plants[2]	Reduction of borers in—	
		Per 100 gallons	Per acre application	Total	Borer-free			Ears	Plants
	Pounds	Pounds	Pounds	Number	Percent	Number	Number	Percent	Percent
DDT (technical) 50 percent, micronized on fuller's earth	2	1.0	1.7	104	97	5	20	97	94
1,1-Dichloro-2,2-bis(p-chlorophenyl)ethane[3] 50 percent on clay	4	2.0	3.4	110	93	9	21	94	94
Chlorinated camphene (technical) 50 percent on Attaclay	4	2.0	3.4	113	92	12	23	92	93
2,2-Bis(3-bromo-5-chloro-2-hydroxyphenyl)-1-trichloroethane 33 percent on pyrophyllite	4	1.33	2.26	103	90	14	29	91	91
Trichloro-bis(methoxyphenyl)-ethane (technical)[4] 50 percent on clay	4	2.0	3.4	102	86	22	40	85	88
1-Trichloro-2,2-bis(3,5-dichloro-2-hydroxyphenyl)ethane 50 percent on pyrophyllite	4	2.0	3.4	102	72	46	86	69	73
Piperonyl butoxide 5 percent + pyrethrins 0.25 percent, on walnut-shell flour	8	0.4 + .02	0.68 + .034	104	86	39	91	74	72

Table 2.--(Continued)

Formulation	Mixture or chemical per 100 gallons	Active ingredient		Yield of No. 1 ears per 100 plants		Borers in ears 1/ from 100 plants	Borers per 100 plants 2/	Reduction of borers in—	
		Per 100 gallons	Per acre-application	Total	Borer-free			Ears	Plants
	Pounds	Pounds	Pounds	Number	Percent	Number	Number	Percent	Percent
Piperonyl butoxide 5 percent, on walnut-shell flour	8	.4	.68	102	71	73	165	51	49
1-Trichloro-2, 2-bis(5-chloro-2-hydroxy-3-nitrophenyl)ethane 33 percent on pyrophyllite	4	1.33	2.26	101	59	90	183	40	43
Check (untreated)	-	-	-	104	43	150	323	-	-
Difference required for significance at odds of 19 to 1	-	-	-	-	-	33	19	-	-

1/ All ears including culls.
2/ Does not include tillers.
3/ Known as TDE.
4/ Known as methoxy analog of DDT.

In 1945 the corn plants showed moderate injury by bis(3,5,6-trichloro-2-hydroxyphenyl)methane, 1-trichloro-2,2-bis(3,5-dichloro-2-hydroxyphenyl)ethane, 1-phenylsemioxamazide, 2-isobutyryl-2-phenylhydrazine, 1-phenyl-2(phenylsulfonyl)hydrazine, and 1-phenyl-2-(p-tolylsulfonyl)hydrazine 2 days after the first application. On July 17, 3 days after the last application, 1-phenylsemioxamazide and bis(3,5,6-trichloro-2-hydroxyphenyl)methane showed moderate injury, and 1-trichloro-2,2-bis(3,5-dichloro-2-hydroxyphenyl)ethane and 1-phenyl-2-(p-tolylsulfonyl)hydrazine showed slight injury. There was no apparent reduction in yield as a result of the use of any material tested.

In 1946, prior to the actual spraying season, the phytotoxicity of all new materials to be used in the small-plot tests was tested by applying them to young corn plants in the field with a hand sprayer. Three successive applications were made, the first on May 29, when the plants were 8 inches high, and the others on May 31 and June 3. The materials were applied in suspensions of 8, 4, and 2 pounds per 100 gallons of water, in sufficient quantity to provide run-off. None of them caused any observable injury to the plants.

In experiments conducted during 1946 with a field-model aerosol generator, highly refined airplane-engine oil applied as an aerosol produced severe burning. Crude soybean oil caused no injury when applied with the same machine, even when the plants close to the machine were covered with sufficient oil to cause run-off. A powder containing 50 percent of DDT applied as a water suspension at the rate of 1/2 pound of the mixture per gallon of water caused no injury to corn or pepper plants when applied with the aerosol generator.

As a further test of tolerance of corn to exceptionally high dosages of DDT, the two buffer rows between each treated plot were sprayed four times at the very heavy rate of 7 pounds of DDT per acre, making a total of 28 pounds per acre. These buffer rows were watched closely for injury to the plants, but none was observed.

Field Tests

DDT, Ryania, and rotenone were tested in 1945 and 1946 in commercial fields containing the earliest planted, most rapid growing market sweet corn. Strips four rows wide extending across the field, replicated three times for each treatment, were sprayed with a two-row self-propelled machine equipped with a stalk-gathering attachment and nozzles which produced solid cones of spray. The stalk gatherers consisted of metal rods, one pair to each row, with one end fastened to the machine so that they were freely adjustable in any direction. These rods lifted the lower leaves of the plants and tillers and held them directly under the spray nozzles as the sprayer passed over the plants. If the sprayer was guided off the row, the gatherers bent the plants into the spray from the nozzles.

Three materials were tested as spray suspensions in 1945--a micronized dust containing 25 percent of DDT on fuller's earth, ground stems of Ryania speciosa, and ground cube root containing 4.8 percent of rotenone. The same materials were tested in 1946 except that the DDT dust contained 50 percent of DDT. Ultrawet (an aromatic monosodium sulfonate) was used as the wetting agent in all sprays at the rate of 1/3 pound per 100 gallons of water.

In 1945 the first application was made on June 25, when the corn was approximately 14 inches high and in the whorl stage. Additional applications were made on June 30 and July 5 and 10. From 170 to 190 gallons of spray were applied per acre-application, larger quantities being used as the plants grew larger. In 1946, all four applications were made at the uniform rate of 175 gallons per acre. At the time of the first application, June 26, the plants were 38 inches high with the tassels beginning to emerge. Additional applications were made on July 1, 6, and 10, and at the roasting-ear stage in both years a total of 50 plants were dissected from the three replicate strips for determining the borer populations. The results are given in table 3.

As in the small-plot tests, the DDT micronized on fuller's earth gave the best control in both years, even though the dosage was only 1/2 pound of DDT per acre in 1945. The results obtained with Ryania were practically the same as those obtained with rotenone in 1945, each giving satisfactory control, but the Ryania appeared to be somewhat more effective in 1946.

Under the comparatively heavy infestation in 1945 there were only 8 No. 1 borer-free ears per 100 plants in check plots as compared with 96 in the plots treated with DDT.

The higher control obtained in 1945 than in 1946 with Ryania and rotenone may have been due partially to the fact that the corn was in the whorl stage in 1945 at the time the applications were made, as higher control is usually obtained at this stage than at the tasseling and silking stages.

Residues of DDT on Sprayed Corn Plants

Samples of green corn plants that had been treated four times with DDT at 1-pound and 7-pound dosages in the small-plot tests were taken at roasting-ear harvest time and sent to the Division of Insecticide Investigations for determination of DDT residues. The chemical analyses showed that, based on the green weights and the organic chlorine found, 0.8 p.p.m. of DDT was present on the unhusked ears and 17.8 p.p.m. on the leaves and stalks of the plants that had been sprayed with DDT at a total of 4 pounds per acre, and 15.0 p.p.m. on the unhusked ears and 190.2 p.p.m. on the leaves and stalks of the plants that had been sprayed with DDT at a total of 28 pounds per acre.

Table 3.--Field-plot tests of DDT, rotenone, and Ryania applied as sprays.

Formulation	Mixture or chemical, per 100 gallons	Active ingredient		Yield of No. 1 ears per 100 plants		Borers in ears[1] from 100 plants	Borers per 100 plants[2]	Reduction of borers in—	
		Per 100 gallons	Per acre-application	Total	Borer-free			Ears	Plants
	Pounds	Pounds	Pounds	Number	Percent	Number	Number	Percent	Percent
Treatments in 1945									
DDT 25 percent, micronized on fuller's earth	2	0.5	0.85-0.95	104	92	12	40	97	96
Ryania speciosa, ground stems	4	4.0	6.8 -7.6	102	90	26	72	93	93
Cube ground root (4.8 percent rotenone)	4	0.19	0.33-0.36	104	85	24	78	93	93
Check (untreated)	-	-	-	118	7	348	1034	-	-
Treatments in 1946									
DDT 50 percent, micronized on fuller's earth	2	1.0	1.75	106	94	6	14	97	96
Ryania speciosa, ground stems	4	4.0	7.0	104	89	12	48	93	87
Cube ground root (4.8 percent rotenone)	4	0.20	0.35	106	79	32	84	82	77
Check (untreated)	-	-	-	106	38	182	362	-	-

1/ All ears including culls.
2/ Does not include tillers.

Summary

Investigations of insecticides appliable as sprays for control of the European corn borer (Pyrausta nubilalis (Hbn.)) were continued during the seasons of 1945 and 1946 in the vicinity of Toledo, Ohio. In small-plot tests thirteen preparations applied with a wheelbarrow sprayer in 1945 reduced the borer population in the plants 89 percent or more. Of the new materials tested in the small-plot tests in 1946, five gave satisfactory control--technical DDT micronized on fuller's earth, 1,1-dichloro-2,2-bis-(p-chlorophenyl)ethane, chlorinated camphene, 2,2-bis(3-bromo-5-chloro-2-hydroxyphenyl)-1-trichloroethane, and trichloro-bis(methoxyphenyl)ethane. None of the five caused spray injury when applied to growing corn plants.

Highly refined airplane-engine oil, one of the carriers used with DDT as an aerosol, caused severe injury to corn plants, but crude soybean oil similarly used caused no apparent injury.

Twenty-eight pounds of DDT per acre applied in four applications as a water suspension caused no observable injury to growing plants.

In comparisons of DDT, Ryania speciosa, and cube powder applied with a self-propelled power sprayer in commercial fields of early-market sweet corn, DDT was the most effective against the borer although very good control was obtained with the other two.

DDT residues amounting to 0.8 and 15.0 p.p.m. were present on roasting ears taken from plots that had been sprayed with DDT at totals of 4 and 28 pounds per acre. Samples of leaves and stalks from the same plots bore DDT residues amounting to 15.0 and 190.2 p.p.m., based on their green weights.

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Check (untreated)	-	-	-	118	7	348	1034	-	-
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DDT 50 percent, micronized on fuller's earth	2	1.0	1.75	106	94	6	14	97	96
Ryania speciosa, ground stems	4	4.0	7.0	104	89	12	48	93	87
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